Influence of Oxygen on Ensiling

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Introduction

Crops are commonly ensiled without proper sealing. Concrete stave tower silos are rarely sealed with plastic after filling, and as a consequence a substantial spoiled layer may develop at the top of the silo prior to the start of emptying. Similarly, bunker silos are frequently not covered. A situation that small farms face is that of having only one silo per crop. Under such circumstances the farmer may feed out of the silo immediately before an adequate fermentation can take place.

The objective of this study was to look at what happens in the first four weeks of ensiling of both alfalfa and corn when the top surface is left open to the air. The goal was to help answer two questions: how far down must one go to find a normally fermented silage and how long must one wait to get a stable silage.

Methods

Alfalfa and whole-plant corn were harvested with normal field equipment. Four cuttings of alfalfa were ensiled at dry matter (DM) contents of 29, 30, 49 and 41%. One trial was performed with corn at 35% DM. The crops were hand-packed into 15 cm dia. x 60 cm long PVC pipe silos. The wet weights ensiled per silo varied with each trial: 7800, 7800, 6600, 6600, 6500 for the four alfalfa trials and one corn trial, respectively. Thus wet densities ranged from 613 kg/m^3 for the corn silage to 736 kg/m^3 for the wettest alfalfa silages. The tops of all silos were kept open to air. The walls were covered with approximately 9 cm fiberglass insulation, and thermocouples placed at 5, 20 and 35 cm from the open face. All silos were stored inside at room temperatures.

Two silos were destructively sampled at 1, 2, 5 (or 3), 7, 14 and 28 d. Samples were taken at 5, 20, 35 and 50 cm from the open face for oxygen content of the silo gas, pH, DM content, fermentation products, nitrogen fractions, and various microbial groups.

Results

In all five trials, oxygen levels at 5 cm below the open face were generally above 10% v/v throughout the 28 d of storage. At the lower levels, oxygen levels were usually below 1% except toward the end of ensiling when oxygen concentrations at 20 cm rose to 1 to 5%. These results indicate that respiration, both plant and microbial, near the open face used up the oxygen entering the silage. By the end of the 28 d period, apparently much of the rapidly degradable compounds in the silage near the face must have been exhausted, allowing oxygen to penetrate further and causing spoilage deeper within the silos. This is also evident from the pH and fermentation data.

The pHs for the wettest and driest alfalfa trials and the corn trial are shown in Figures 1 to 3, respectively. In spite of the high oxygen levels at 5 cm, there was evidence of fermentation early in the storage period in the two wettest alfalfa trials and in the corn trial (Fig. 1, 3). However this forage rapidly spoiled as noted by the high pHs at later times. In the alfalfa, the primary spoilage microorganisms in this layer were bacilli and/or acetic acid bacteria. Yeasts and molds were not a significant factor over 28 d. In corn, acetic acid bacteria and yeasts dominated early spoilage in the upper layer. Later bacilli and mold counts rose to significant levels in the corn silage.

At 20 cm and deeper from the surface, fermentation proceeded in an apparently normal fashion in all trials, most likely due to the low oxygen levels. The time to reach a minimum pH in alfalfa was between 7 to 14 d across the four trials. In contrast, the corn fermented rapidly (less than 5 d) to a stable, low pH. By day 28, the pH at 20 cm was beginning to rise in some of the

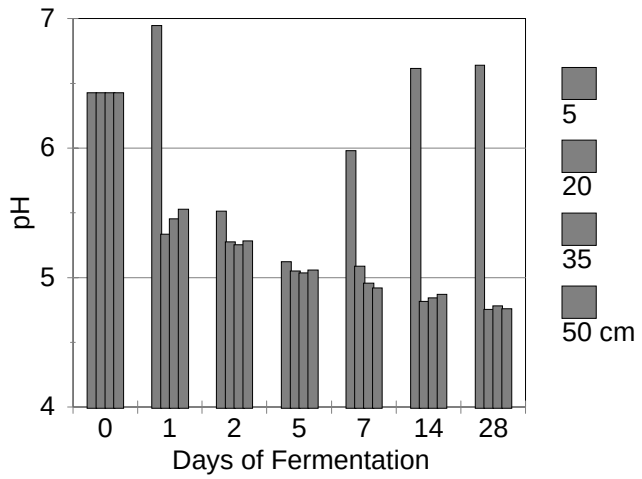

Figure 1. Change in pH in 29% DM alfalfa after ensiling with respect to time and depth from the open face.

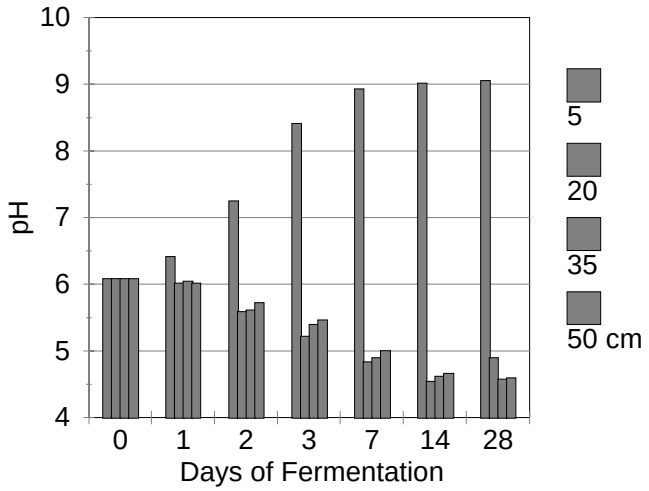

Figure 2. Change in pH in 49% DM alfalfa after ensiling with respect to time and depth from the open face.

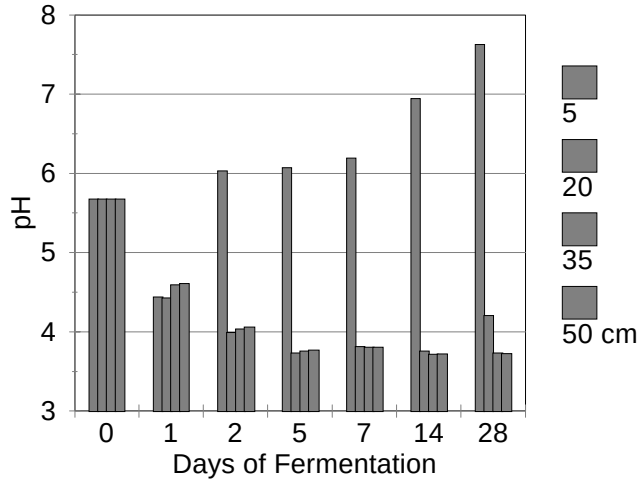

Figure 3. Change in pH in 35% DM corn after ensiling with respect to time and depth from the open face.

trials (e.g., Fig. 2 and 3) and fermentation products were declining, indicating the activity of spoilage microorganisms. At 28 d at the 20 cm level, bacilli were the predominant spoilage group in alfalfa whereas all major spoilage groups were at substantial levels in corn.

Additional time beyond that for active fermentation is usually necessary for populations of aerobic spoilage microorganisms to be reduced. This is desirable to make a silage which is not susceptible to heating and spoilage during feeding. At the two locations farthest from the face of the corn silage, yeast and acetic acid bacteria were still at high levels ($>10^6$ per g silage) after fermentation was complete (day 5) and did not drop below 10^5/g until the sampling at days 14 and 28, respectively. At day 14 in alfalfa, bacilli were above 10^5/g in two cases and acetic acid bacteria were above that level in the other two. Yeasts and molds were at low levels in all the alfalfa silages after one week.

Conclusions

At moderate silage densities and DM contents between 30 and 50%, a normal fermentation occurred consistently at 20 cm below a face open to air at temperatures of 20 to 25°C. However, there was substantial spoilage at 5 cm, and in most trials spoilage was becoming evident at 20 cm by the end of the 28-day trial. In both alfalfa and corn, substantial levels of one group of spoilage microorganisms were still present after 14 days ensiling at the most anaerobic levels in the silos. These results suggest that a one month ensiling period prior to feeding is beneficial in reducing aerobic spoilage microorganisms.